The Butterflies of Pohnpei, Eastern Caroline Islands, Micronesia[1]

Donald W. Buden[2] and Jacqueline Y. Miller[3]

Abstract: Fourteen species of butterflies are recorded from Pohnpei, Micronesia, seven for the first time. None is endemic to the island; all are widely distributed in the western Pacific, including parts of Indo-Australia, with many extending into or beyond southeastern Asia. A long history of plant introductions and agricultural experimentation may have facilitated dispersal of butterflies to the island and provided a broad selection of host plants for those arriving otherwise unassisted. At least one, and possibly two or more, unidentified species apparently confined to deep forest habitats were seen but not collected during this study. Compared with the local odonate fauna, the butterflies of Pohnpei differ in reaching their greatest abundance and species diversity in the lowlands, in lacking endemic species, and probably in having a higher turnover rate.

In the most recent and comprehensive assessment of the distribution and status of butterflies in Micronesia, Schreiner and Nafus (1997) recorded five species on Pohnpei: *Jamides bochus*, *Danaus plexippus*, *Hypolimnas bolina*, *Junonia villida*, and *Melanitis leda*. Earlier reports on Pohnpei butterflies are scanty, sketchy, and scattered among several obscure and for the most part not readily available journals. A collection of butterflies assembled from the field surveys of the Insects of Micronesia Project described in Gressitt's (1954) introduction was sent on loan to someone in Japan many years ago and apparently has since been lost (S. E. Miller, pers. comm.); there has never been a report published on butterflies in the Insects of Micronesia publication series. This lack of available information and paucity of records provided incentive for our further investigation into butterfly diversity on Pohnpei. Our study doubles the number of species recorded from the island and is based largely on collections and observations from throughout the island during March 2000–September 2001.

Study Area

Pohnpei (6° 52′ N, 158° 13′ E) is the largest (355 km^2 [MacLean et al. 1986]) and highest island (approximately 800 m), and the capital, of the Federated States of Micronesia (FSM), which also includes Yap, Chuuk (formerly Truk), and Kosrae States (Figure 1). Warm, wet conditions persist year-round on Pohnpei. The average annual temperature is 27°C, and the monthly average does not vary from that by more than 1°C (Laird 1982). The high rainfall—485 cm annually in the lowlands and up to 1015 cm estimated for the mountains (Merlin et al. 1992)—contributes to a lush tropical vegetation. Densely forested ridges and valleys radiate outward and downward from the central highlands. Mosses, ferns, and other epiphytes festoon the trees and shrubs of the cloud forest, usually occurring above 600 m. A tropical rain forest dominated by broadleaf trees reaching 30 or more meters high covers much of the area between 200 and 600 m, with the endemic kotop palm (*Clinostigma ponapensis*) forming nearly pure stands on plateaus and gentle slopes, especially above about 450 m. The clearing of numerous small 1- to 2-ha plots

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[2] Corresponding author: Division of Natural Science and Mathematics, College of Micronesia—FSM, P.O. Box 159, Kolonia, Pohnpei FM 96941 (phone: 691-320-2480; fax: 691-320-2479; E-mail: don_buden@comfsm.fm).

[3] Allyn Museum of Entomology, Florida Museum of Natural History, 3621 Bay Shore Road, Sarasota, Florida 34234 (E-mail: jmiller@virtu.sar.usf.edu).

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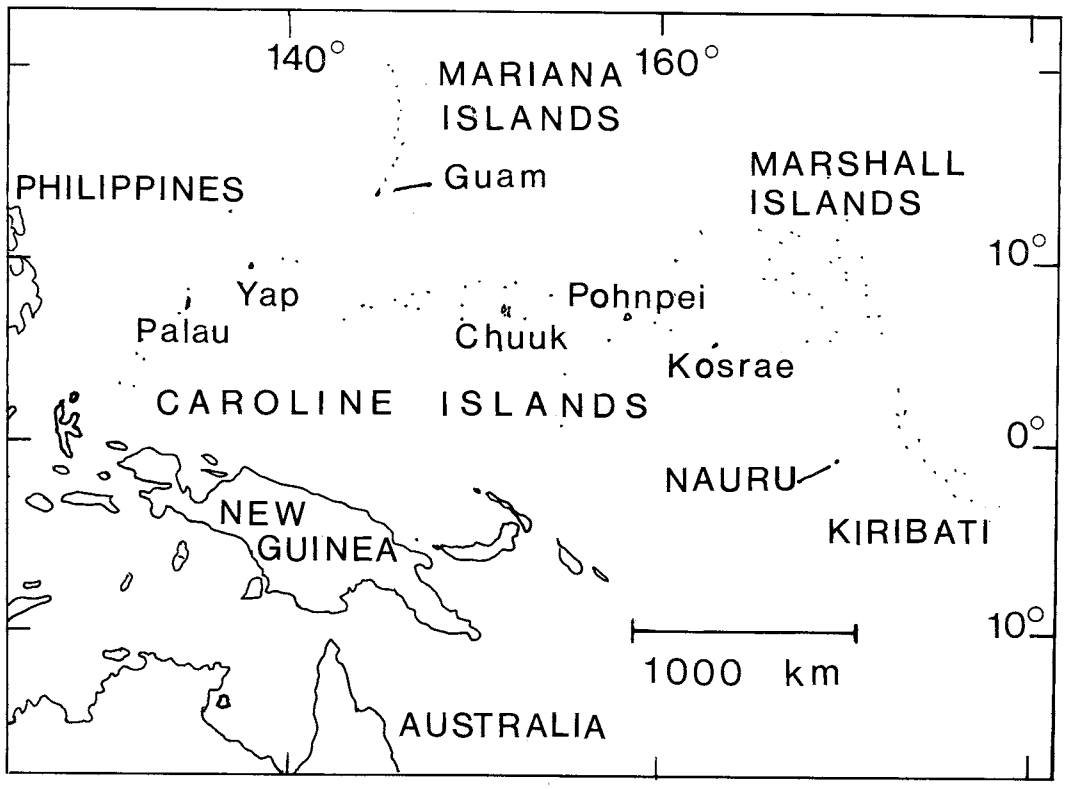

FIGURE 1. Location map of Pohnpei and surrounding western Pacific islands.

for the cultivation of sakau (= kava, *Piper methysticum*) has been steadily encroaching deeper and higher into this forest; Trustrum (1996) reported a decline in intact native upland forest from 42% of the total vegetation cover in 1975 to 15% in 1995.

The lowlands (below 200 m) include mainly secondary woodland and areas otherwise modified for subsistence agriculture and human occupation; some intact rain forest occurs at the upper extreme. Approximately 8000 of the nearly 35,000 islanders live in Kolonia; the others are distributed in smaller settlements along the 87-km-long circumferential road. Spur roads extend short distances into the interior but none traverses the island; the central highlands are uninhabited. Mangroves form nearly a continuous belt around the island, covering about 55 km^2 (Petteys et al. 1986). A barrier reef encloses a lagoon with numerous volcanic and coral reef islands, the largest and nearest of which (Sokehs, Takaieu, and Temwen) are connected to mainland Pohnpei by causeways.

MATERIALS AND METHODS

Specimens were collected opportunistically and intermittently throughout the island by D.W.B. during March 2000–September 2001. The more remote montane forest regions were visited by backpacking for 2–4 days at a time. Localities were identified using a topographic map (U.S. Geological Survey 1983), an altimeter (Barigo) scaled in 20-ft (6.1-m) increments, and a global positioning system (GPS) navigator (Garmin III Plus) where the canopy did not block satellite reception. All specimens were deposited in the collections of the Allyn Museum of Entomology (Sarasota, Florida), American Museum of Natural History (New York), Bishop

Museum (Honolulu), and CSIRO Long Pocket Laboratory (Indooroopilly, Australia).

Species recorded for the first time in Pohnpei appear in boldface type in the species accounts. The name Pale pea-blue for *Catochrysops panormus* follows Braby (2000), whereas all other English names follow Schreiner and Nafus (1997).

SPECIES ACCOUNTS

Hesperiidae

Badamia exclamationis (Fabricius). Brown skipper.

Previously recorded in Micronesia from Palau, the Marianas, and the Marshall Islands (Schreiner and Nafus 1997). The nine specimens collected in Kolonia and vicinity during 12–16 September (5), 22 April 2000 (2), and 2–15 September 2001 (2) are the first for Pohnpei. All were on or near *Terminalia catappa*. Caterpillars and pupae of *B. exclamationis* occasionally were observed in the rolled or folded-over leaves of *Terminalia*, and the many damaged leaves with ragged edges presumably had been eaten by these larvae.

Pieridae

Catopsilia pomona (Fabricius). Lemon migrant.

Previously recorded in Micronesia only from westernmost islands, in Palau and the Marianas (Schreiner and Nafus 1997). The 21 specimens collected during this study are the first reported from Pohnpei. *Catopsilia pomona* is one of the most common species in the lowlands, especially along roadsides in wet areas where the candle flower, *Cassia alata*, is present. It was abundant also in the vicinity of a *Cassia fistula* tree in bloom at the Agricultural Experiment Station in Kolonia in June 2000, where 20 to 30 were in view at any one time.

Catopsilia pyranthe (Linnaeus). Common migrant.

Previously recorded in Micronesia in Palau and Yap (Schreiner and Nafus 1997). One collected on a roadside adjacent to a taro patch on Temwen Island on 30 April 2000, and another in a seepage area with *Cassia alata*, taro, and banana on Takaieu Island on 1 September 2001 are the only records for Pohnpei. This species is more abundant than the scanty records indicate. It occurs syntopically with *C. pomona* but is less common, with an estimated ratio of about 1:30.

Lycaenidae

Acytolepis puspa (Horsfield). Common hedge blue.

Matsumura (1915) described *Cyaniris* (= *Acytolepis*) *puspa watasei* as a new "variety" (subspecies) from Angaur (Palau) and Pohnpei, but he did not indicate island localities for individual specimens. He reported that the new form differed from the "type" in its smaller size, narrower marginal black bands on the wings, and smaller patches (= spots?) on the undersurface of the wings. Schreiner and Nafus (1997) reported *A. puspa* from Palau but did not mention Pohnpei in their account.

Catochrysops panormus (C. Felder). Pale pea-blue.

Schreiner and Nafus (1997) reported *Catochrysops amasea* from Palau, Yap, and Chuuk, and no other congeners in Micronesia. Semper (1906) recorded *C. strabo* from the Caroline Islands [Micronesia] and made no mention of *C. amasea* or any other congeners in his account. Twenty-nine specimens of *Catochrysops* were collected on Pohnpei, in the vicinity of Kolonia, during our study. Twenty of them were critically examined by J.Y.M. and identified as *C. panormus* based on the wing and genitalic characters described in Corbet and Pendlebury (1978) and Seki et al. (1991), and three others from this series were identified by D. Sands also as *C. panormus*. We include the remaining six also under *C. panormus* though we did not examine them critically and the identifications by colleagues to whom they were sent were uncertain.

Catochrysops panormus is widely distributed from India to Sri Lanka and the Philippines southward through Indonesia to northern and eastern Australia, and eastward to the Solomon Islands, Vanuatu, and the Loyalty

Islands (Tite 1959, Seki et al. 1991, Braby 2000). It has also been recorded in Micronesia on Guam (Parsons 1999). The specimens from Pohnpei are the first records for the genus on the island and the first for the species in the Federated States of Micronesia. We have not examined examples of *Catochrysops* from elsewhere in Micronesia and cannot comment further on the identification of those recorded as *C. amasea* and *C. strabo*.

Larval host plants recorded for this species include many legumes (Fabaceae) among the genera *Phaseolus*, *Dolichos*, *Cajanus*, *Crotalaria*, *Dendrolobium*, *Flemingia*, and *Galactia* (Seki et al. 1991, Parsons 1999, Braby 2000). Most of the Pohnpei specimens were collected on or near *Dendrolobium* sp. in coastal strand, and the others were in adjacent grassy, weedy areas.

Jamides bochus (Stoll). Cerulean.

Previously recorded in Micronesia in Palau and Pohnpei (Schreiner and Nafus 1997). There is one specimen deposited at Bishop Museum collected on Pohnpei by Z. Ono without further data. Another specimen was collected by the same collector on Palao Island (= Palau) in the Caroline Islands on 4 May 1936. None was encountered on Pohnpei during our survey, although the host plants listed by Schreiner and Nafus (1997), including *Crotolaria mucronata*, *Derris trifoliata*, and *Vigna marina*, are common along the shore and on the lagoon islands.

Zizina otis (Fabricius). Lesser grass blue.

Previously recorded in Micronesia from Yap, the Marianas, and Chuuk (Schreiner and Nafus 1997). The only record for Pohnpei is a specimen collected in short grass and weeds on the Palikir campus of the College of Micronesia on 28 September 2000 and sent to the Bishop Museum, where it was identified to species by D. Preston.

Zizula hylax (Fabricius). Tiny grass blue.

Previously recorded in Micronesia from Yap, the Marianas, and Chuuk (Schreiner and Nafus 1997). Ten specimens collected in short grass and weeds on the Palikir campus of the College of Micronesia during 20–28 September 2000 are the only records for Pohnpei. Larval host plants elsewhere include *Hygrophila angustifolia* and *Ruellia tuberosa* (Acanthaceae) (Braby 2000).

Danaidae

Danaus plexippus (Linnaeus). Monarch.

Widespread throughout Micronesia; occurring on all major islands or island groups with the possible exception of Kosrae (Schreiner and Nafus 1997). This species was apparently introduced to Pohnpei from Hawai'i via a shipment of "milkweeds" in 1857 (Gulick in Scudder 1875), but more likely as a stowaway adult than as eggs, larvae, or pupae (Scudder 1875). *Danaus plexippus* is especially common around settlements, usually in close proximity to crown flowers, *Calatropis gigantea*, a common ornamental.

Euploea abjecta Butler. Sicle-spotted brown crow.

Schreiner and Nafus (1997) recorded this species in Micronesia only from Palau, where they considered it common. Matsumura (1915) reported it from Angaur (Palau) and Pohnpei. He described coloration and pattern but gave no additional details regarding locality data for specimens collected.

Nymphalidae

Hypolimnas bolina (Linnaeus). Blue moon or Common egg-fly.

Recorded on all the major island groups in Micronesia, including Palau, the Marianas, Yap, Chuuk, Pohnpei, Kosrae, and the Marshall Islands (Schreiner and Nafus 1997). It is the most common species on Pohnpei, at least in the lowlands, especially in settled areas and along roadsides. The variety of female forms and different expanses of orange on the forewing are particularly noteworthy.

Hypolimnas pithoeka Kirsh. Dark egg-fly.

Previously recorded in Micronesia only on Kosrae (Schreiner and Nafus 1997), which is one of the easternmost islands and one of the most distant from potential source populations in the Indo-Australian-Melanesian region. Of the six Kosraen specimens in the

Bishop Museum collection, four were collected at elevations between 800 and 1200 ft (244–366 m) by H. K. Townes in August 1946. The two others are undated and lack additional locality data, but were collected by Z. Ono, all of whose specimens from Pohnpei we examined were collected in 1936.

Eighteen *H. pithoeka* collected by D.W.B. during 18 October 2000–18 August 2001 are the first reported for Pohnpei. This species is widely distributed throughout the island but much more numerous in montane forest than in the lowlands, which probably contributes to the absence of previous records. One each were collected at 73 and 92 m, eight at 200–400 m, three at 401–600 m, and five in cloud forest or rain forest/cloud forest transition at 601–800 m. *Hypolimnas pithoeka* does not usually occur under the forest canopy but has a predilection for open, sun-exposed sites, including mountain ridges and summits, and forest edges bordering grasslands, fern brakes, marshes, and agricultural plots (mainly sakau patches). It tends to be territorial, returning to the same perch even when repeatedly disturbed during unsuccessful attempts at capture, and it is usually seen paired or in small groups of three or four that tend to stay within and circuit very circumscribed areas usually covering less than 0.5 ha. Some freshly emerged females may appear similar in coloration to males with a faint indication of the bluish white postmedian band on the forewing. Hopkins (1927) recorded the larval host plant as *Cudrania* sp. near *javanensis* (Urticaceae), a common epiphyte in Samoa, but on Papua New Guinea *H. pithoeka* subspp. utilize the herbaceous weed *Sida rhombifolia* (Malvaceae) (Parsons 1999).

Junonia villida (Fabricius). Meadow argus.

Previously recorded in Micronesia from Palau, Chuuk, Pohnpei, and the Marshall Islands (Schreiner and Nafus 1997). It probably was common on Pohnpei at least until the mid-1900s, but is now extremely scarce if still extant. The Bishop Museum has 13 specimens from Pohnpei obtained by three different collectors (Z. Ono, H. K. Townes, S. Uchiyama) at eight different localities during April 1927 (2), February and March 1936 (6), and August 1946 (5). In addition, Hirose (1934) reported seven males collected on 23 December 1933, and Matsumura (1915) considered it common on Pohnpei and elsewhere in Micronesia. However, none was collected nor positively identified in the field during our study. Occasional sightings (one for every 4–5 days in the field) of orange and brown butterflies in the well-shaded understory of the rain forest may have included this species. Two observed briefly but at close range (within about 2 m) appeared to have a wing pattern similar to that of *J. villida*, but another more closely resembled *Vanessa indica*, with its distinctive orange markings on the forewings; other sightings were too brief and at too great a distance for even tentative identifications. None of these orange and brown butterflies was observed in the lowlands in the more open, grassy, weedy areas representing habitat seemingly more suitable for *J. villida* (and *V. indica*).

Satyridae

Melanitis leda (Linnaeus). Evening brown.

Widely distributed throughout Micronesia, being unrecorded only in the Marshall Islands (Schreiner and Nafus 1997). On Pohnpei, it is common in dense grassy, weedy areas, from the lowlands to the highest peaks. Specimens are markedly reduced in size with occasionally a faint indication of orange on the proximal margin of the dorsal forewing ocelli.

DISCUSSION

Of the 14 species of butterflies recorded from Pohnpei, none is endemic; all range widely in the West-central Pacific, occurring also in at least parts of Indo-Australia and often extending well into or beyond southeastern Asia. Adler and Dudley (1994) reported that the Pacific butterfly fauna was derived largely from Australia, New Guinea, and Asia, and that isolation from potential source areas is the most important geographic variable explaining variation in species richness among these islands. S. E. Miller (1996) cited numerous examples of comprehensive biogeo-

graphic studies involving at least six different orders of insects wherein a progressive diminution of species occurred west to east across the Pacific Basin. The number of species of butterflies recorded for Micronesia by Schreiner and Nafus (1997) demonstrates this attenuation from west to east (away from primary source areas), with at least 41 species on Palau, 22 on Yap, 20 on Guam, 9 on Chuuk, 5 on Pohnpei, 4 on Kosrae, and 4 in the Marshalls. The seven additional species recorded on Pohnpei during this study, together with earlier records of *Acytolepis puspa* and *Euploea abjecta* that were not included in Schreiner and Nafus (1997), increase the Pohnpei list by nearly threefold to 14 and is a perturbation in this otherwise smooth sequence; Pohnpei now has five more species than does Chuuk. Possibly Chuuk is incompletely surveyed. Also, some species recorded earlier in Pohnpei but not recently may no longer be extant. On the other hand, Pohnpei, being markedly larger than Chuuk (355 km^2 versus 117 km^2 divided among numerous islets), higher (approximately 800 m versus 435 m), and with a more diverse flora (at least 438 native vascular plant species recorded versus 298 [Fosberg et al. 1979, 1982, 1987 in Falanruw, unpublished report submitted to FSM Advisory Panel for National Biodiversity Strategy and Action Plan]), might be expected to support a larger butterfly fauna despite its more remote location 710 km farther east. Furthermore, the dispersal of butterflies to Pohnpei may have been facilitated by the introduction of plants possibly bearing eggs or larval stages and serving also as hosts for species that arrived otherwise unassisted. The probable introduction of *Danaus plexippus* to Pohnpei via a shipment of milkweeds (*Asclepias* sp.) from Hawai'i was reported by Scudder (1875). Ragone et al. (2001:290) stated that "Pohnpei has been a center for plant introductions in Micronesia for more than 100 years," and that "the Pohnpei Agriculture Station ... [was] once one of the foremost centers in the world for the study of tropical agriculture...." They (Ragone et al. 2001: appendix 1) listed 395 species of plants (along with additional hybrids, cultivars, and varieties) documented as having been brought to Pohnpei from 33 different islands or countries, both tropical and temperate, mainly during the Japanese administration, 1914–1945.

The absence of butterflies endemic to Pohnpei or to any of the other remote Caroline Islands fits a pattern described by Adler and Dudley (1994) for the Pacific islands as a whole, wherein the largest and nearest to potential source areas have the greatest number of endemics. They (Adler and Dudley 1994) suggested that constraints of host plant specificity and the mechanics of insect-plant coevolution may impede diversification among these more remote populations. It is of at least passing interest that compared with butterflies, 8 (53%) of the 15 species of Odonata (dragonflies and damselflies) recorded on Pohnpei are endemic to the island (Paulson and Buden in press). Odonates, like butterflies, are relatively large, visually conspicuous, diurnal fliers, but they have very different life history patterns, including larvae that are aquatic carnivores as opposed to terrestrial herbivores, and the absence of host plant specificity. Compared with butterflies, the odonate population of Pohnpei also appears more stable over time. All 14 species recorded during the 1940s and 1950s (Lieftinck 1962), along with one undescribed presumed auctochthon (Paulson in press), but no other species, were collected by one of us (D.W.B.) during the course of this study. Six of them represent a radiation within the damselfly genus *Teinobasis*. On the other hand, the current list of butterflies differs from earlier versions in both the apparent absence of previously recorded species (*Acytolepis puspa*, *Jamides bochus*, *Euploea abjecta*, and possibly *Junonia villida*) as well as the addition of those recorded for the first time.

The absence of *Eurema hecabe* from Pohnpei lists is somewhat surprising in view of its widespread occurrence elsewhere in the Pacific (Schreiner and Nafus 1997) and the availability of many of its leguminous host plant species on the island. Possibly it was present but undetected in the past. The Bishop Museum has one specimen recorded from Chuuk and another from Kosrae (thus bracketing Pohnpei), both collected by Z.

Ono in 1936. Schreiner and Nafus (1997) did not encounter this species during more recent visits to these islands and suggested that the species is rare or that the two specimens (the only records) may be mislabeled.

The recent additions of *Catopsilia pomona*, *C. pyranthe*, *Catochrysops panormus*, and *Melanitis leda* to the Pohnpei list probably represent very recent colonizations or recolonizations, or at least recent population expansions because these species are common, conspicuous, and not likely to have escaped detection in their current numbers during earlier surveys. *Badamia exclamationis*, *Zizina otis*, and *Zizula hylax* are less conspicuous and possibly were overlooked by previous collectors. Whether *Hypolimnas pithoeka* is a recent arrival or a long-term resident that has avoided detection in part because of its scarcity in the lowlands is less certain. Of the 10 species of butterflies identified in the field during this study, only *H. pithoeka* was more abundant in the upland forest than in the lowlands; *Melanitis leda* was common in grassy areas throughout. The eight others were encountered only in the lowlands, chiefly settled areas, roadsides, and coastal strand.

There remains the issue of the identity of probably two different species of small to medium-sized, extremely wary orange and brown butterflies that are seldom encountered and only in the forest understory. Whether they are species previously reported from the island (at least two sighted resembled *Junonia villida*) now occurring atypically in deep forest, or whether they represent range extensions for a species as yet unrecorded on Pohnpei, or possibly examples of as yet undescribed species, or some combination thereof is unknown and high priority for further investigation.

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